VERY HIGH CRYSTAL QUALITY DIAMOND STUDIED BY A VARIETY OF SYNCHROTRON GENERATED X-RAY TECHNIQUES

S. H. Connell, R. K. Setshedi, D. Dube, L. Mkhonza, M Rebak

Physics Department, University of the Witwatersrand, Johannesburg

J. Härtwig and J. Hoszowska

European Synchrotron Radiation Facility (ESRF), Grenoble

RC Burns, JO Hansen

Element Six, Johannesburg

Keywords: diamond, synchrotron, optic elements.

Abstract

The unique properties of diamond have identified it as one of the most attractive materials for application in a range of beam optical elements associated with modern very bright X-ray sources. This new role for diamond imposes rigorous standards of crystalline quality. The question presents itself as to whether diamond can be synthesized to adequate levels of perfection. This has motivated the present study of very high quality type IIa diamond crystals synthesised using the high pressure high temperature technique (HPHT) by Element Six in Johannesburg. The X-ray characterizations were carried out at various beam lines of the ESRF Synchrotron Facility. They included high resolution synchrotron x-ray rocking curve mapping and X-ray topography using both the white beam and plane wave methods in the Laue and Bragg geometries. These methods are sensitive to extended defects like dislocations, stacking faults, growth sector boundaries, strain fields and precipitates. The samples exhibit excellent bulk properties which improve with distance from the seed face. The rocking curve maps display essentially the Darwin line width in the central cubic growth sector, which appears essentially free of extended defects, and where the spatial variation of the lattice constant is in the $\Delta d/d \sim 10^{-8}$ range. The impurity concentration is sufficiently low that growth sectors observed by UV phosphorescence show almost no phase contrast in the topographs. The partial coherence of the beam in the modern X-ray sources is a crucial property for several applications such as coherent imaging, extreme focusing and photon correlation spectroscopy. A robust way to characterise the coherence properties of the wave front at the exit of an optical element is the Talbot effect (self-imaging of a periodic object in propagation). Coherence preservation measurements of this type using synchrotron radiation have also been made. Taken together, these results are very promising for a new role of diamond as a synchrotron beam optic element in even the most demanding of applications.